中国船舶港口排放清单研究

Research on Emission Enventory of Ship and Harbor in China

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内容提要
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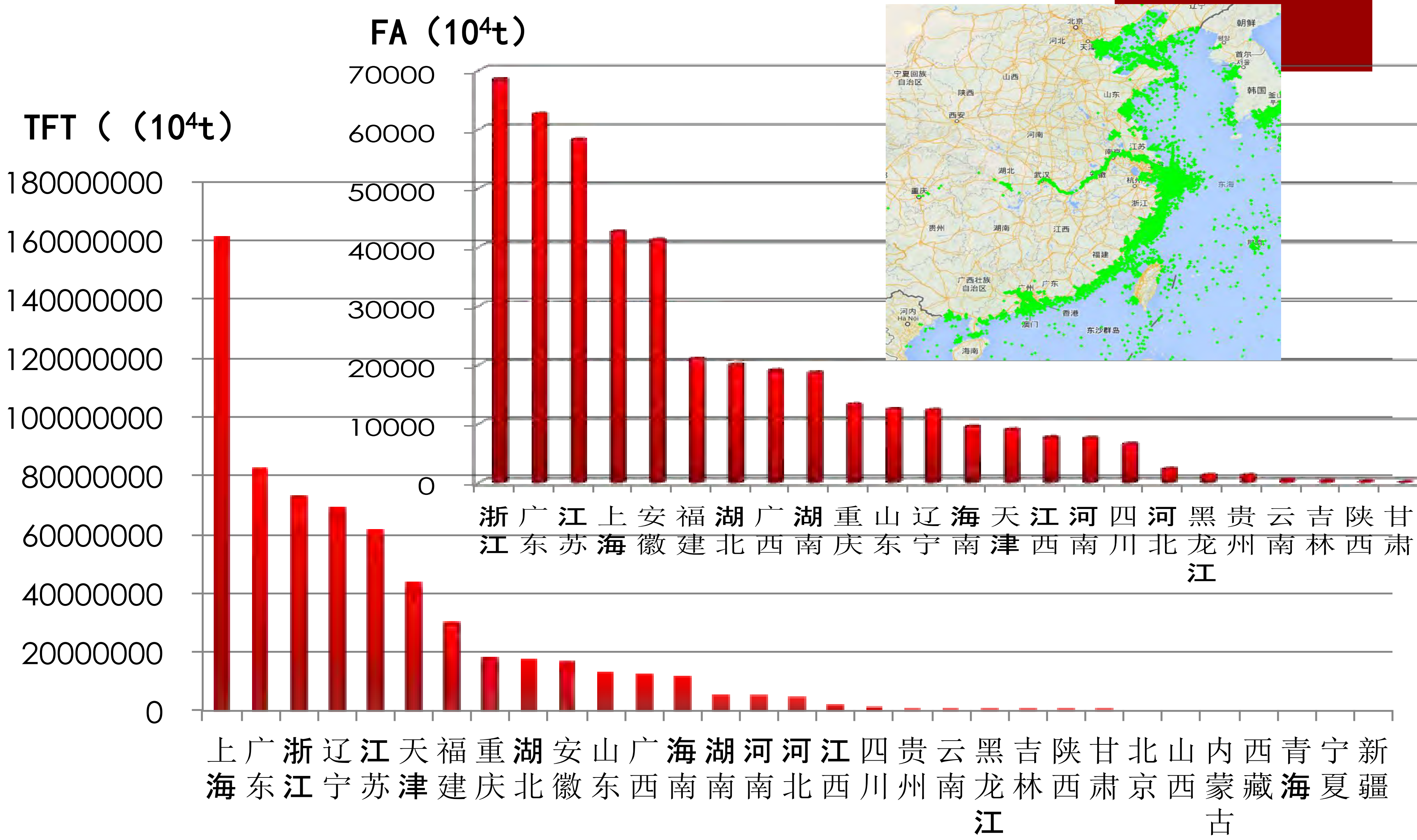
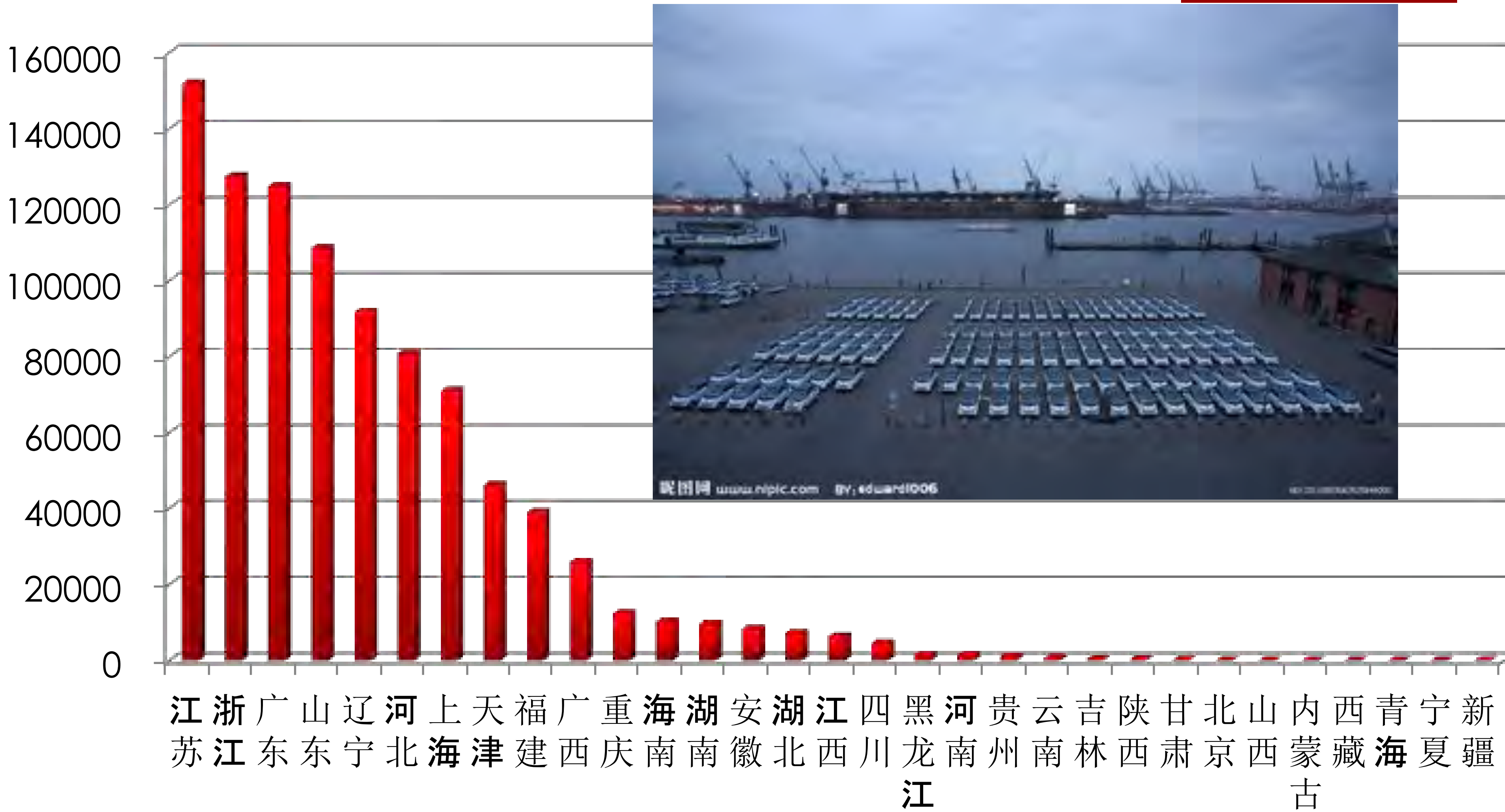
  Ship and Harbor Transportation in China
- 动态排放清单的模型架构
  Model Construction of a dynamic emission inventory
- 污染物排放清单案例分析
  Case Studies of pollutants emission inventory
- 防治对策组合及效果评估
  Combination of reduction countermeasures and effect evaluation

中国大陆水路货运量和货物周转量

Freight amount and turnover of freight traffic of Chinese mainland(2013.01～11)

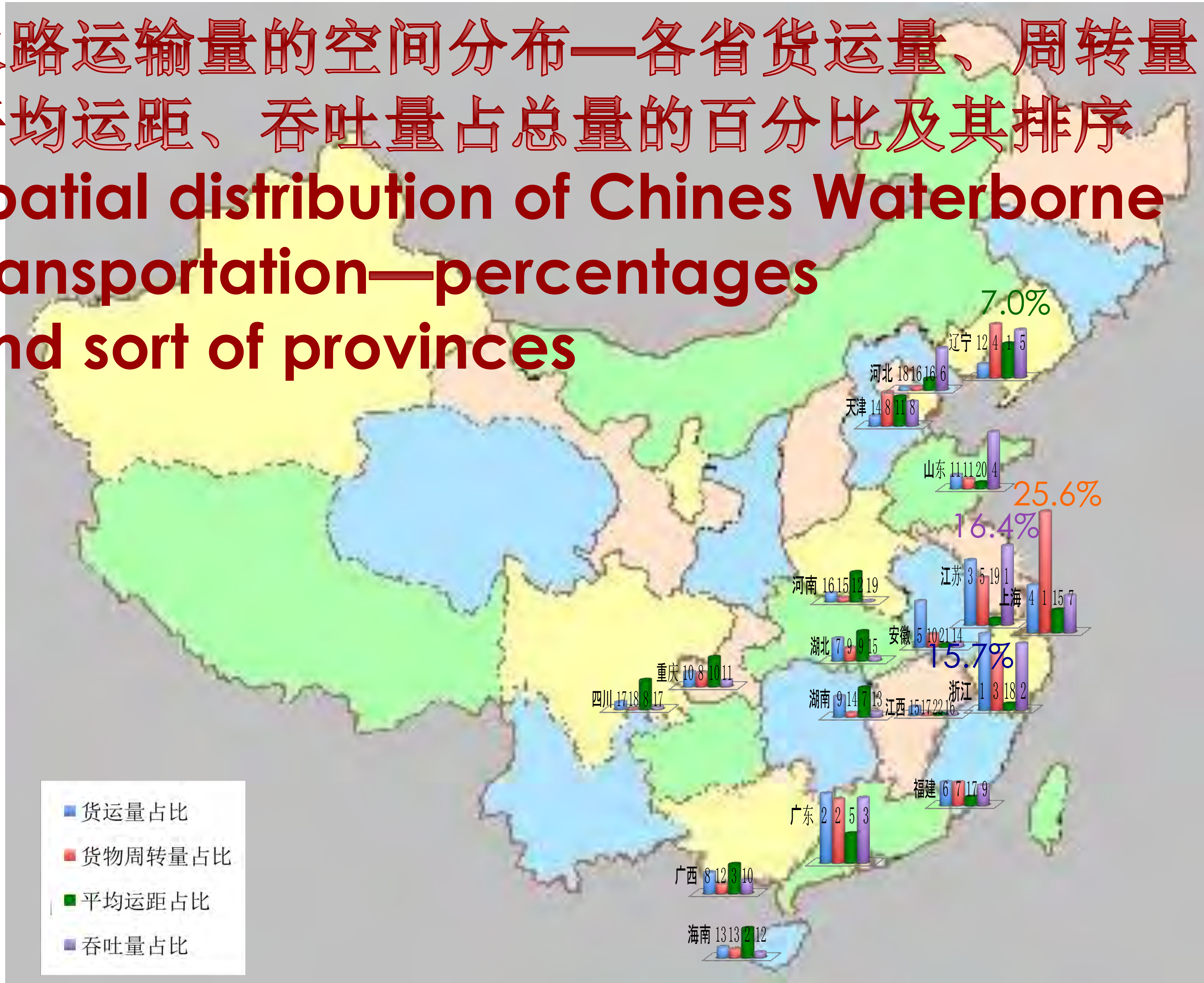


中国大陆各省主要港口吞吐量
Cargo-handling capacity of China Port（2013.01～11） 万吨



水路运输量的空间分布—各省货运量、周转量、平均运距、吞吐量占总量的百分比及其排序

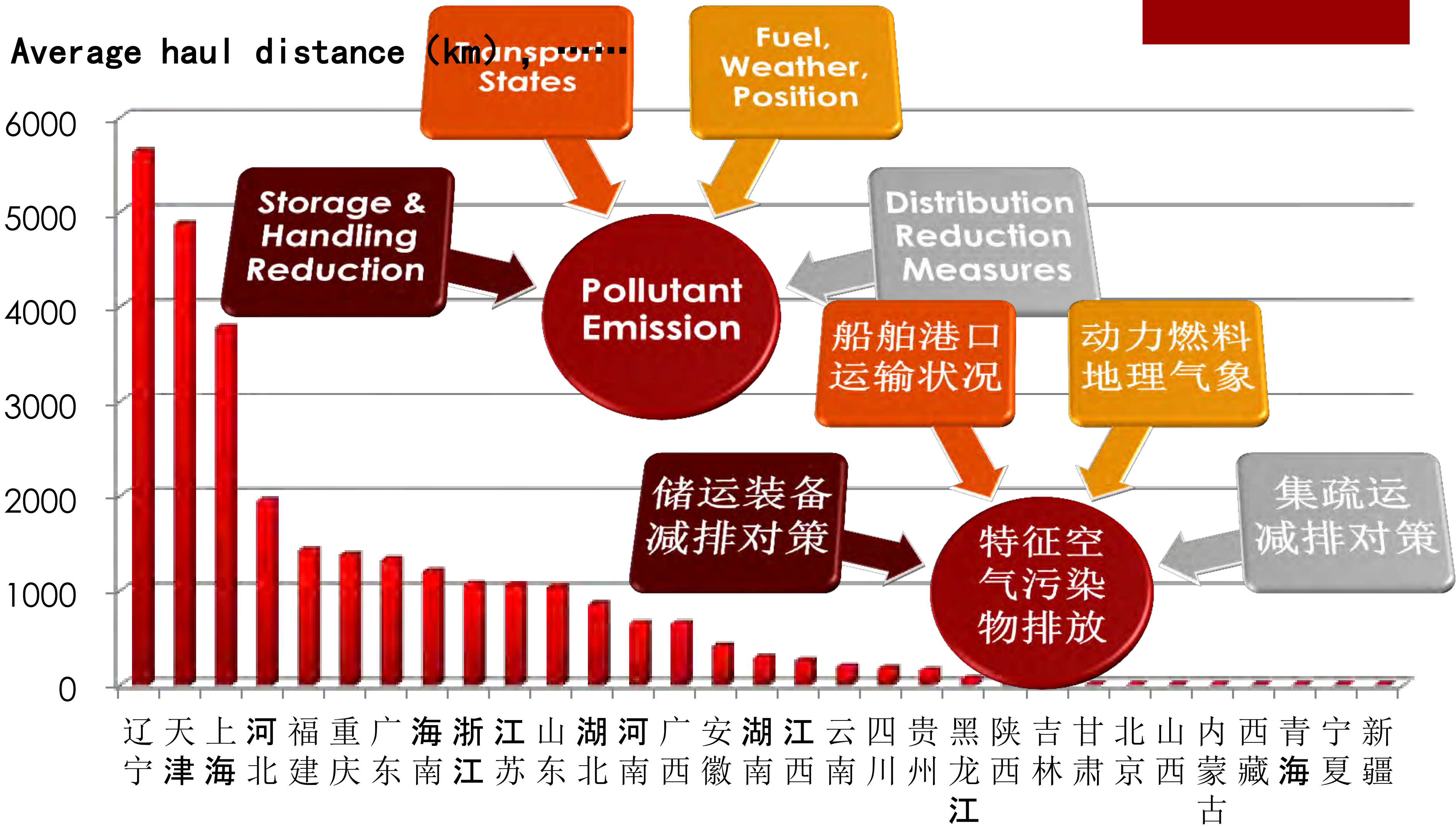
Spatial distribution of Chines Waterborne Transportation—percentages and sort of provinces



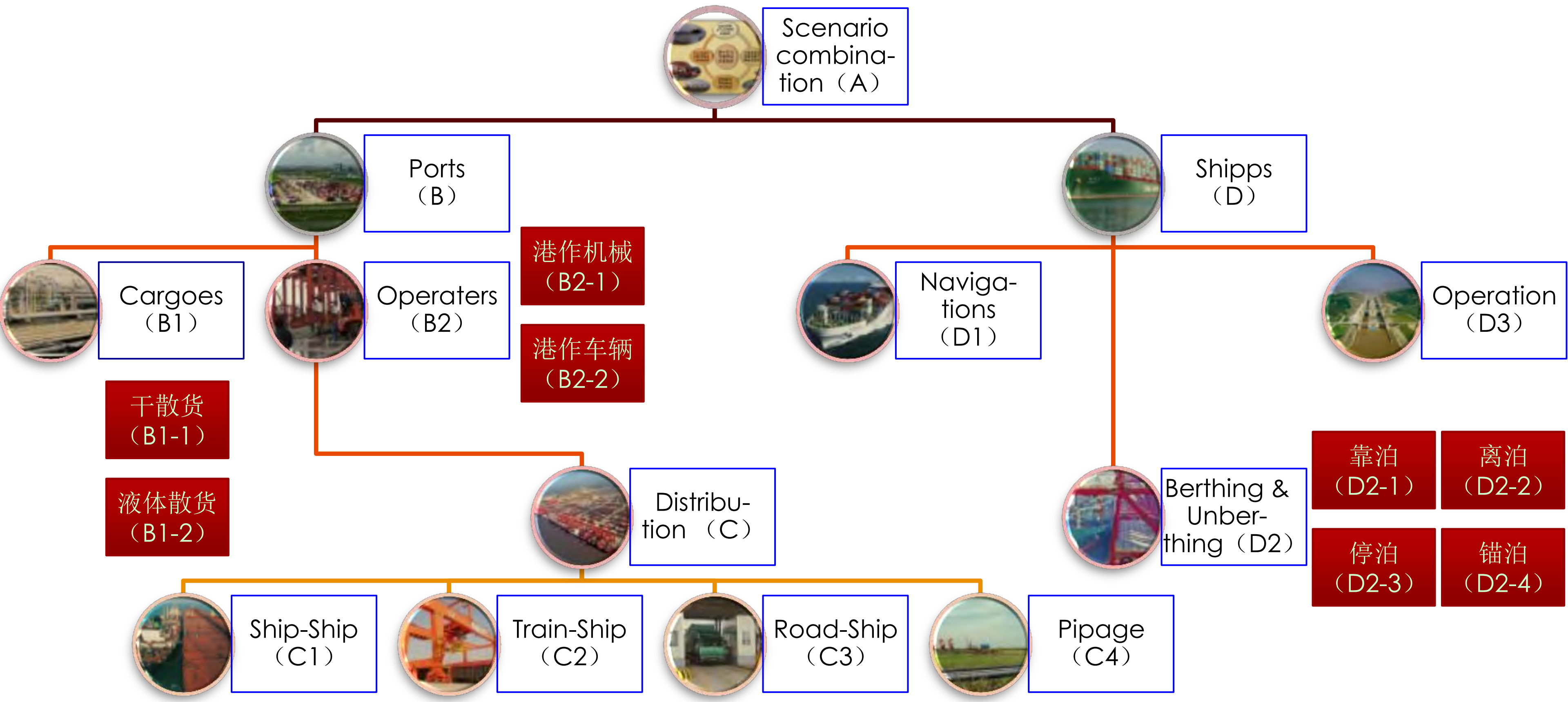
水路运输量的空间分布分析
Spatialdistribution of Concentrated Areas of Harbor and Shipping

- Zhejing、Jiangsu、Shanghai
  - 货运量分别名列第**1**、3、4名
  - 吞吐量分别名列第2、**1**、7名
  - 周转量分别名列第3、2、**1**名
  - 平均运距分别名列第18、19、15名
- Guangdong、Hubei、Hunan、Henan
  - 货运量分别名列第2、7、9、16名
  - 吞吐量分别名列第3、15、13、19名
  - 周转量分别名列第2、9、14、15名
  - 平均运距分别名列第5、9、10、12名
- Shandong、Liaoning、Tianjin、Hebei
  - 货运量分别名列第11、12、14、18名
  - 吞吐量分别名列第4、5、8、6名
  - 周转量分别名列第11、4、8、16名
  - 平均运距分别名列第20、**1**、11、16名
- Anhui、Fujian、Jiangxi
  - 货运量分别名列第5、6、15名
  - 吞吐量分别名列第14、9、16名
  - 周转量分别名列第10、7、17名
  - 平均运距分别名列第21、17、22名
- Guangxi、Hainan
  - 货运量分别名列第8、13名
  - 吞吐量分别名列第10、12名
  - 周转量分别名列第12、13名
  - 平均运距分别名列第3、2名
- Chongqing、Sichuan
  - 货运量分别名列第10、17名
  - 吞吐量分别名列第11、17名
  - 周转量分别名列第8、18名
  - 平均运距分别名列第10、8名

船舶港口排放的主要影响因素
Main Factors Influencing Ship and Harbor Emissions



动态排放清单的模型架构
Model Construction of a dynamic emission inventory



动态排放清单的模型求解方法
Model Solving Methods

- 情景模拟法（运营状况、减排对策、环境条件）
- 公式计算法（典型排放因子排放量）
- 统计分析法（吞吐量、船舶活动量、货物周转量等）
- 抽样调查法（装卸设备、引航、靠离泊、待泊时间）
- 现场实测法（煤炭粉尘起尘量、粒径分布、油气等）
- 机理分析法（光化学反应、对策效果等）
- 类比分析法
- 经验估算法

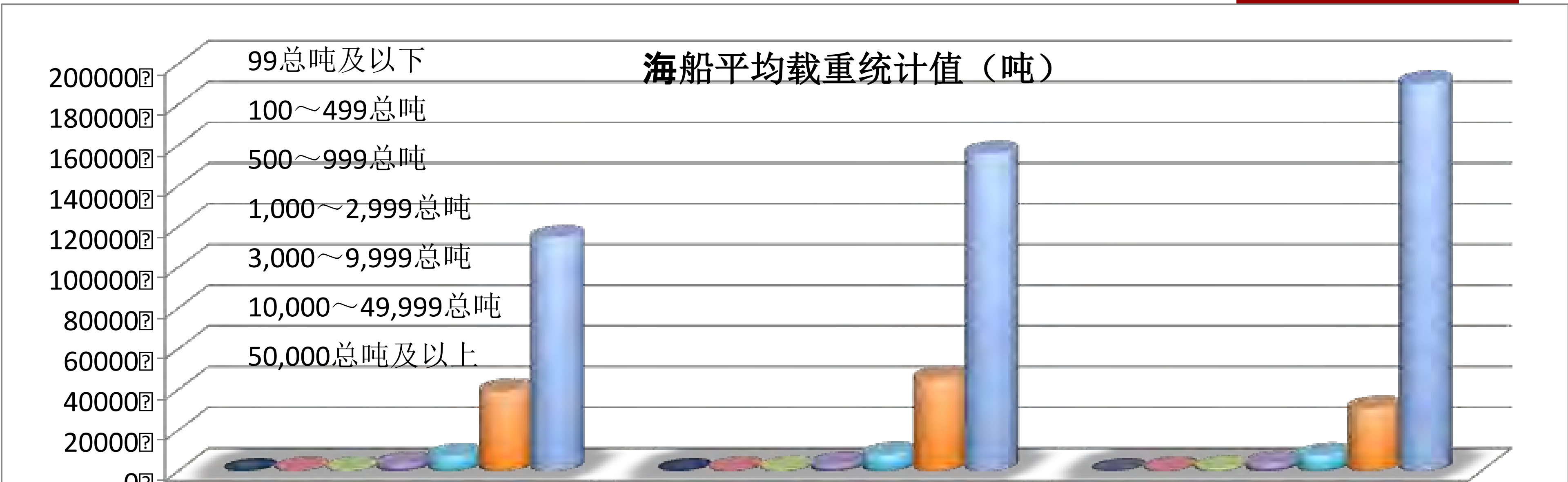
- Scenario Combination（Operation States; Reduction Countermeasures; Weather Condition）
- Formulas（Pollutant Emission Amount）
- Statistical Analysis（Cargo-handling Capacity; ship activity; Turnover of Freight traffic ）
- Sampling Survey（Handling Facilities; Pilot; Berthing & Unberthing time）
- Field Measure（Coal dust; Size distribution; VOCs）
- Mechanism analysis（Photo-chemical Reactions; Countermeasures Effect）
- Analogy Analysis
- empirical estimate

货物周转量及船舶数量、运距估算 Turnover of Freight traffic and Ship amount, haul distance

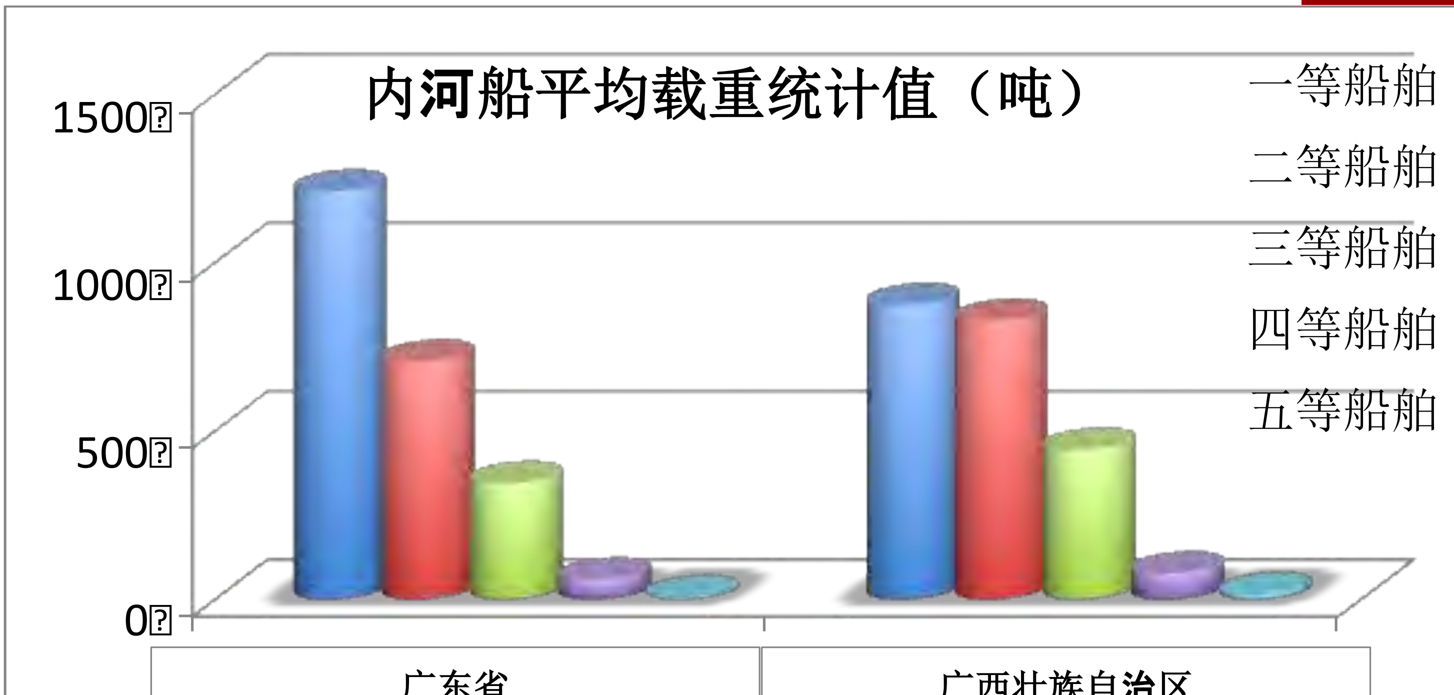
- 货物周转量（万吨公里）$_m$＝ 实际运送货物重量（吨）$_m$× 10^{-4} × 货物平均运距（公里）$_m$
- 实际运送货物重量（吨）$_m$＝∑［海船平均载重$_{i,k}$（吨/艘）× 海船数量$_{i,k}$（艘）］＋∑［内河船平均载重$_{j,k}$（吨/艘）× 内河船数量$_{j,k}$（艘）］
- 进出港船舶数量（艘）$_m$＝∑［∑海船数量$_{i,o,k}$（艘）＋ ∑内河船数量$_{j,k}$（艘）］
- 船舶累积运距（公里）$_n$＝∑［［海船数量（艘）$_{i,k,m}$ ×货物平均运距（公里）$_{i,k,m}$］＋［内河船数量$_{j,k,m}$（艘）×货物平均运距（公里）$_{j,k,m}$］

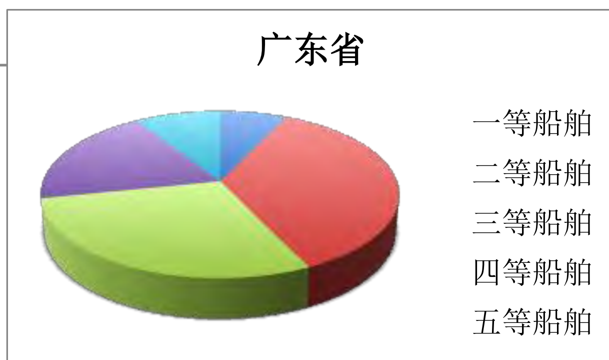
注：i：海船吨级分级；j：内河船吨级分级；
o：海船类型（散货、集装箱、杂货、顶推、其他）；
k：省内港口；m：省、自治区、直辖市；n：区域、全国

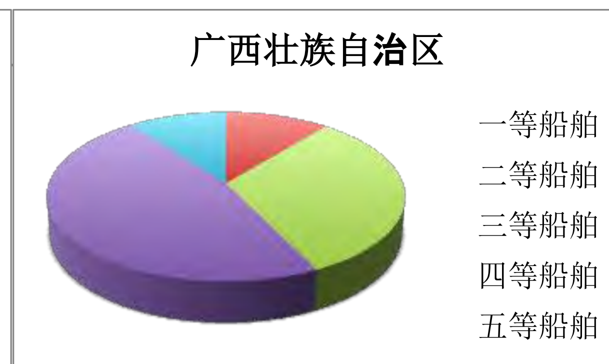
海船载重吨级及数量占比抽样分析
Marine ship carrying capacity and number Sampling Survey



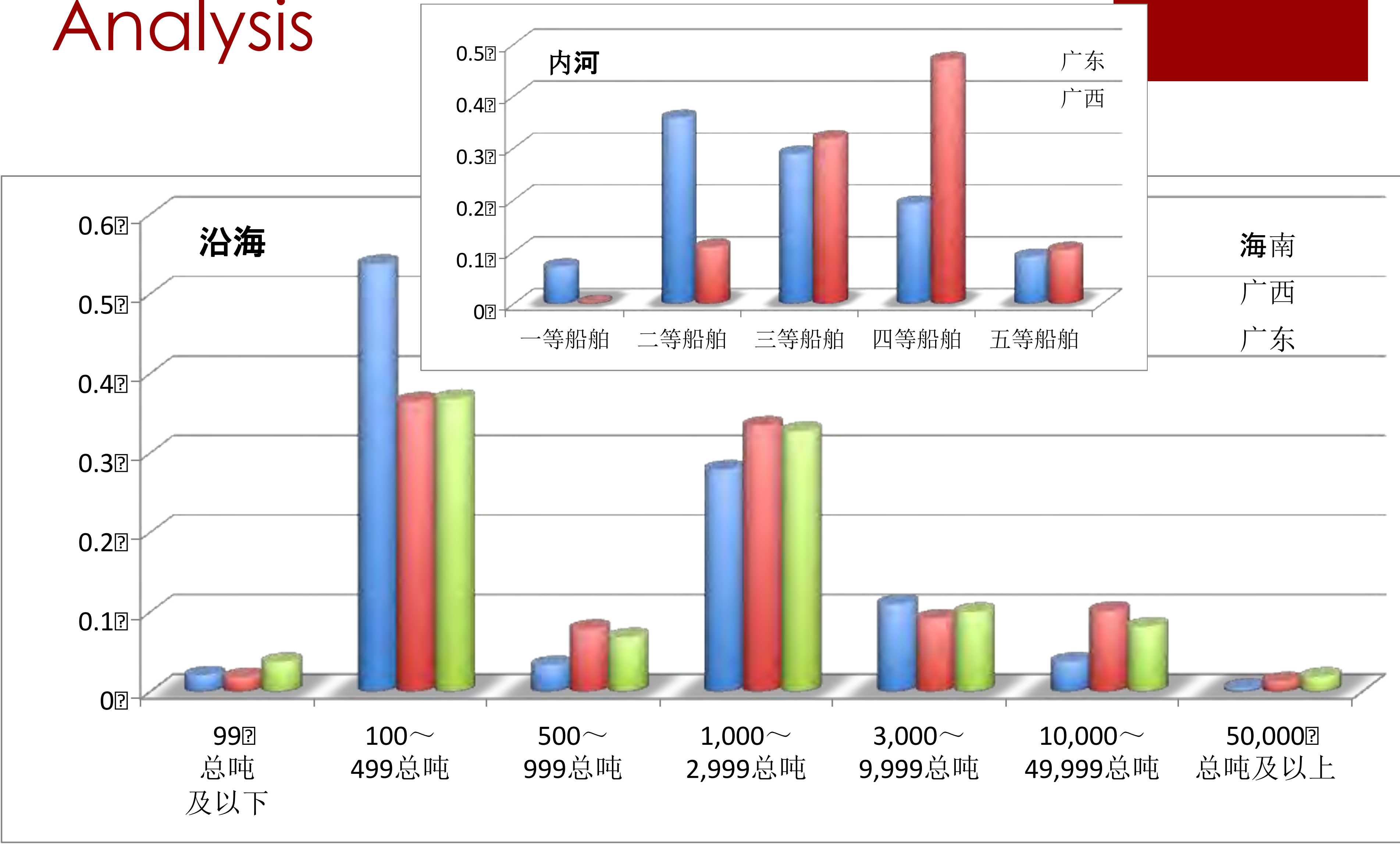
内河船载重吨级及数量占比统计分析 River ship carrying capacity and number Sampling Survey







进出港船舶吨级占比抽样分析
carrying capacity proportion Analysis

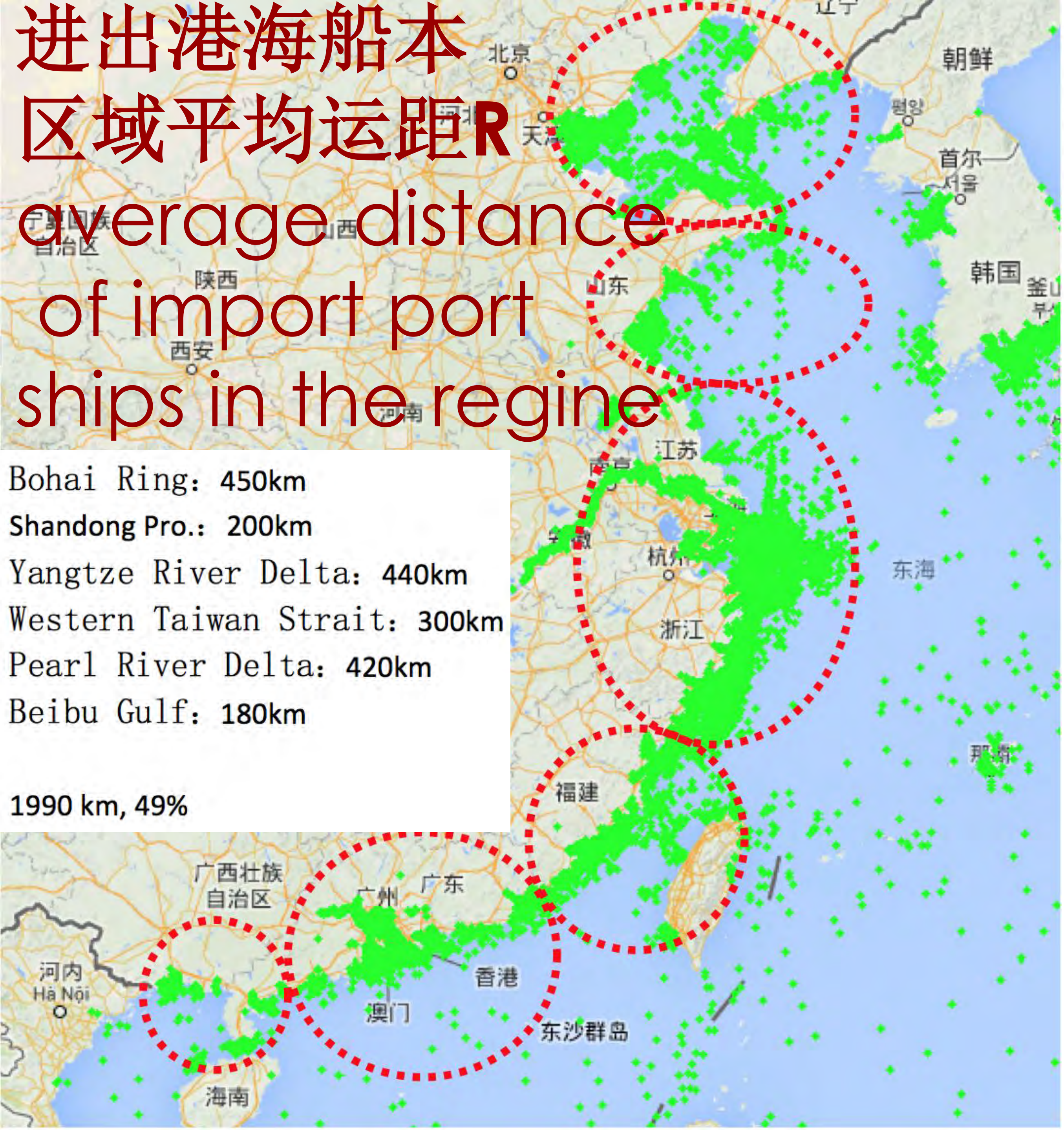


进出港海船本区域平均运距R

average distance of import port ships in the regine

Bohai Ring：450km
Shandong Pro.：200km
Yangtze River Delta：440km
Western Taiwan Strait：300km
Pearl River Delta：420km
Beibu Gulf：180km

1990 km, 49%



Bohai Ring：120km
Yangtze River Delta：620km
Western Taiwan Strait：260km
Pearl River Delta：350km
Beibu Gulf：720km

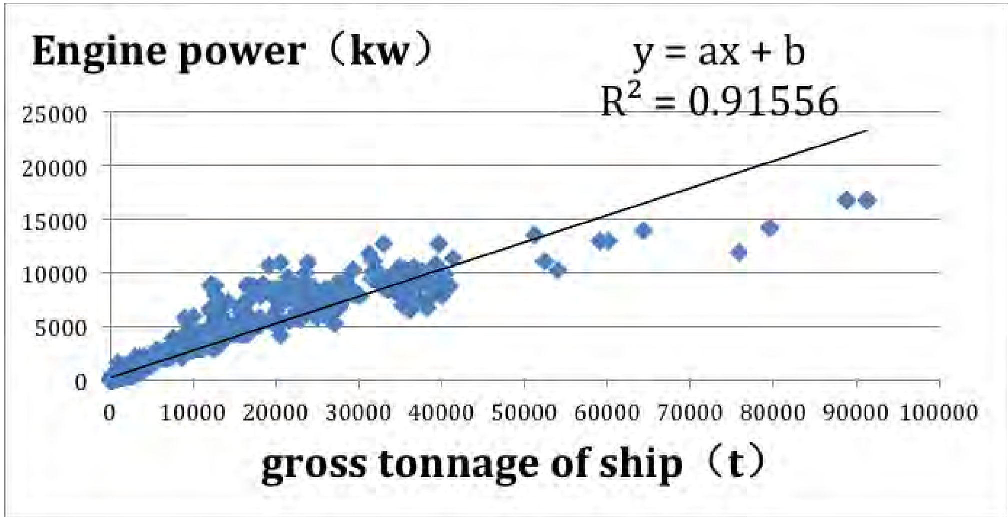
2070 km, 51%

区域外及内河船舶的折合平均运距

Equivalent average distance outside the regine and inner ship

船舶排放模块（D）发动机额定功率MCR、活动时间（T）Ship emission module（D）：engine power(MCR), activity time（T）

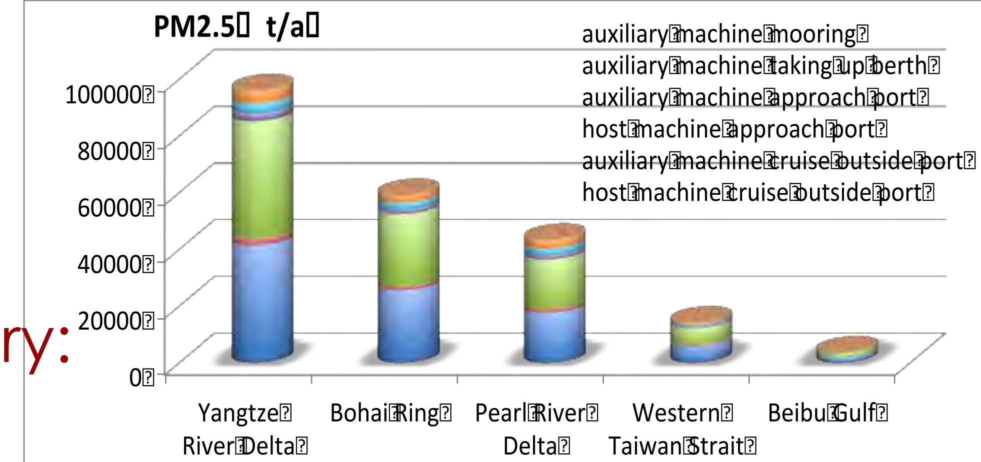
- 巡航、靠离泊（各类船舶主机、100吨级以上船舶副机）Cruise, berthing and unberthing（host machines, auxiliary machines over 100 tones）
  - $MCR_{i,o} = A_{i,o} \times W_{i,o} + B_{i,o}$
  - $T1_{i,o,m} = R_{i,o,m} / V_{i,o} \times C_{i,o,m}$
- 停泊、锚泊
  taking up a berth、mooring（auxiliary machines over 100 tones）
  - $T2_{i,o,m} = TH_{i,o,m}$
  - $T3_{i,o,m} = TW_{i,o,m}$
- 作业、施工船舶Construction ship
  - $T4_{i,o,m} = TO_{i,o,m}$
- A、B、C:统计系数
  Statistical coefficient

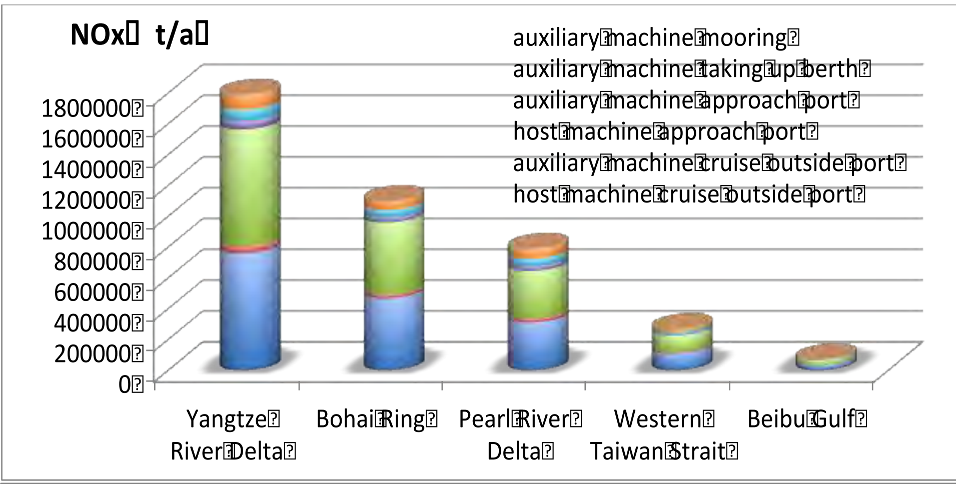


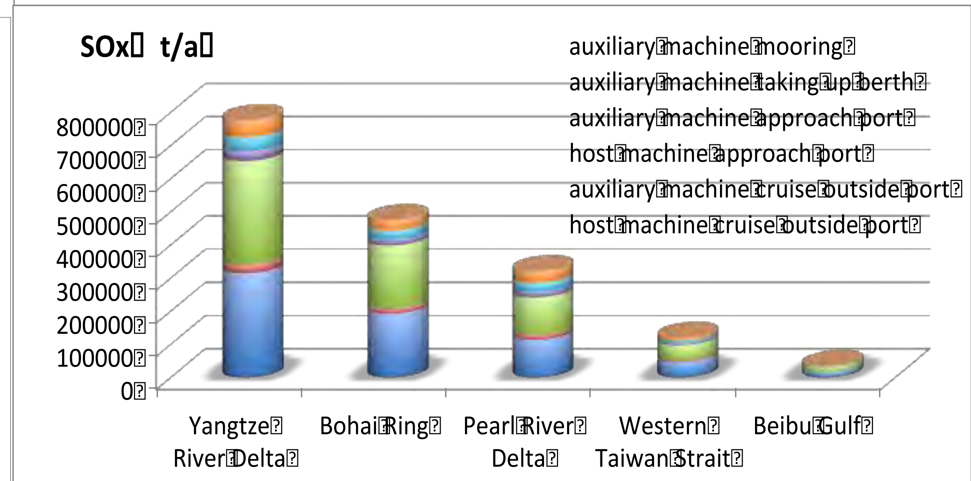
主机重油、副机高硫柴油情景下船舶排放清单

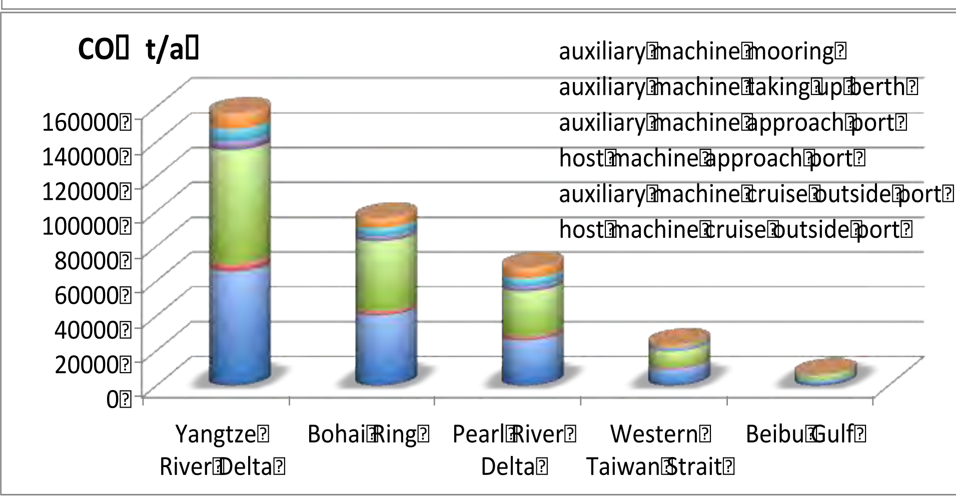
Emission scenario

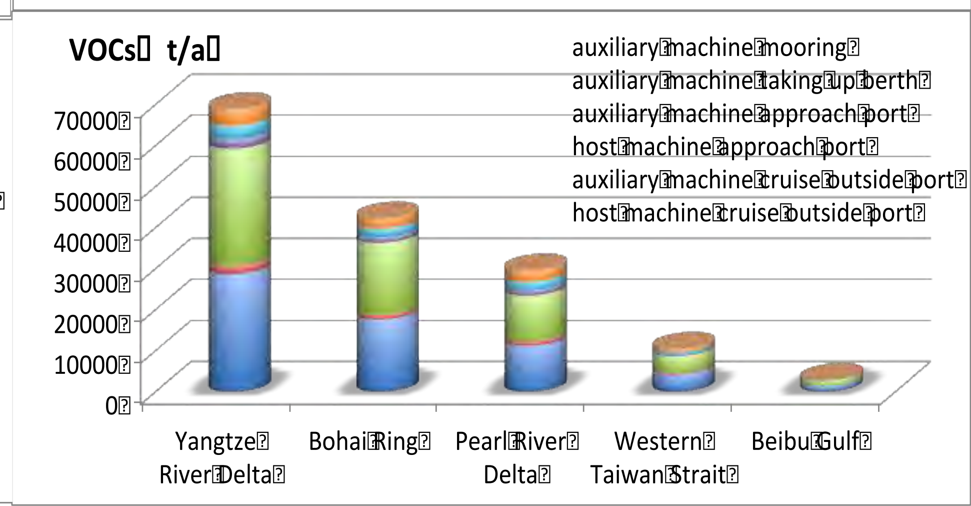
host：Heavy oil；、auxiliary: 1.5%S diesel







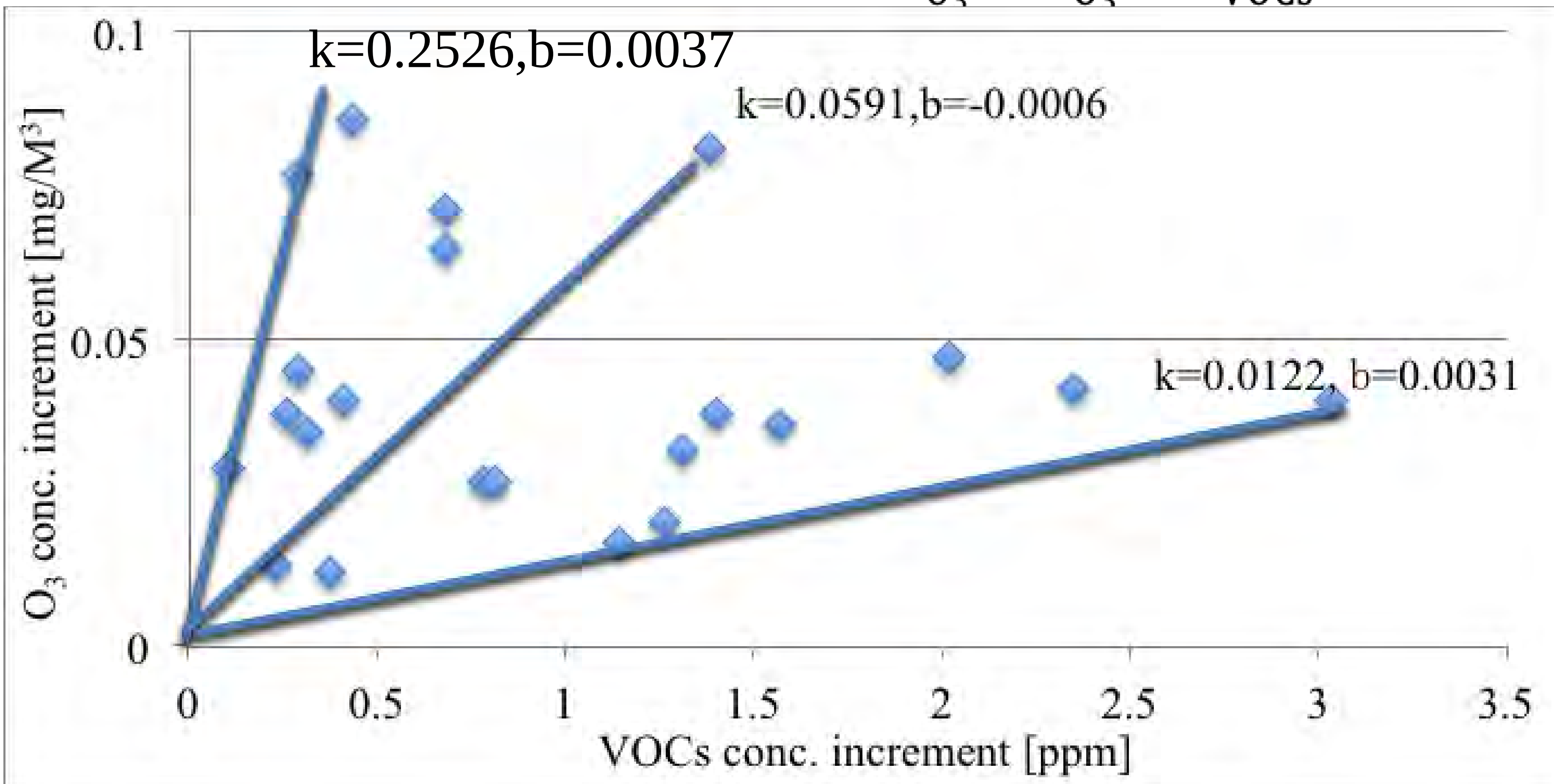




石油码头VOCs排放及其光化学反应产物O_3的现场实测结果分析

Measured O_3 Production OF VOCs Photochemical Reaction

At Same Time & Same Position $\Delta C_{O_3} \cong k_{O_3} \times \Delta C_{VOCs}$



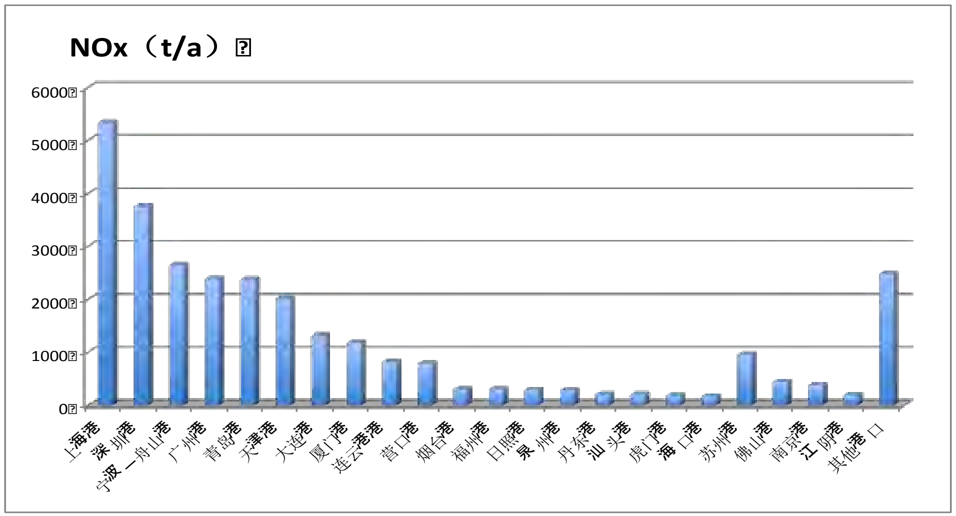
中国大陆港口群密集区域石油码头排放量VOCs ,PM Emission amount of VOCs and PM in port group area in 2012 [t]

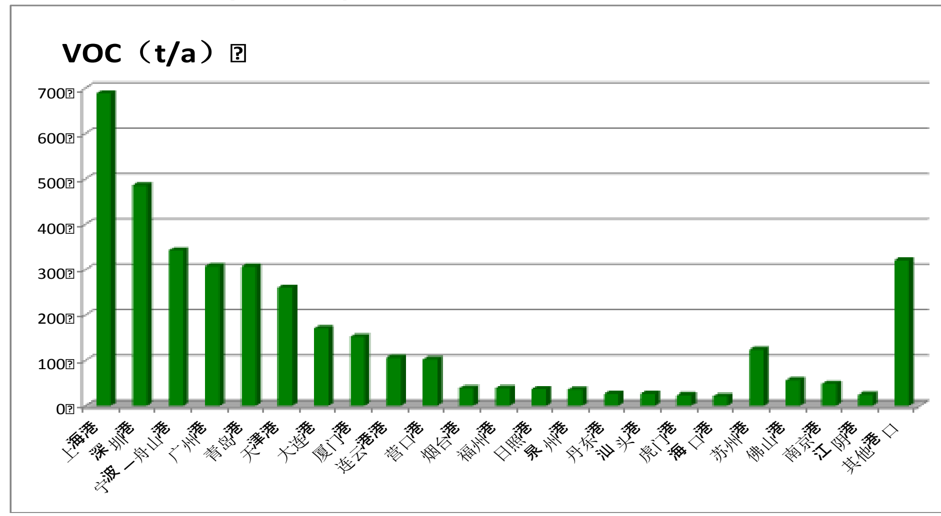
area	Yangtze River Delta	Bohai Ring	Pearl River Delta	Beibu Gulf	Western Taiwan Strait
VOCs	15587	9924	3940	2794	2778
PM	2210	1407	559	396	394
port name	Ningbo-Zhoushan, Suzhou, Shanghai, Nanjing, Nantong, Huzhou, Zhenjiang, Jiangyin, Taizhou, Jiaxing	Tianjing, Tangshan, Dalian, Qinhuangdao, Yantai	Guangzhou, Zhuhai, Humen, Fushan, Shenzhen	Beibuwan, Haikou, Yangpu	Xiamen, Fuzhou, Quanzhou, Shantou

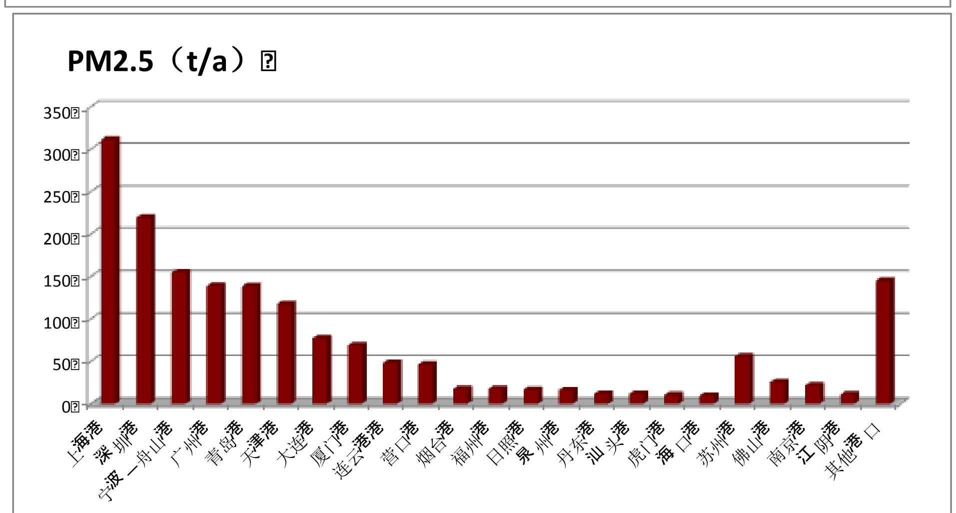
Zhijie Fan et (1990) VOCs from oil shipments in 2000 would be 9500 ~ 16000 t in China

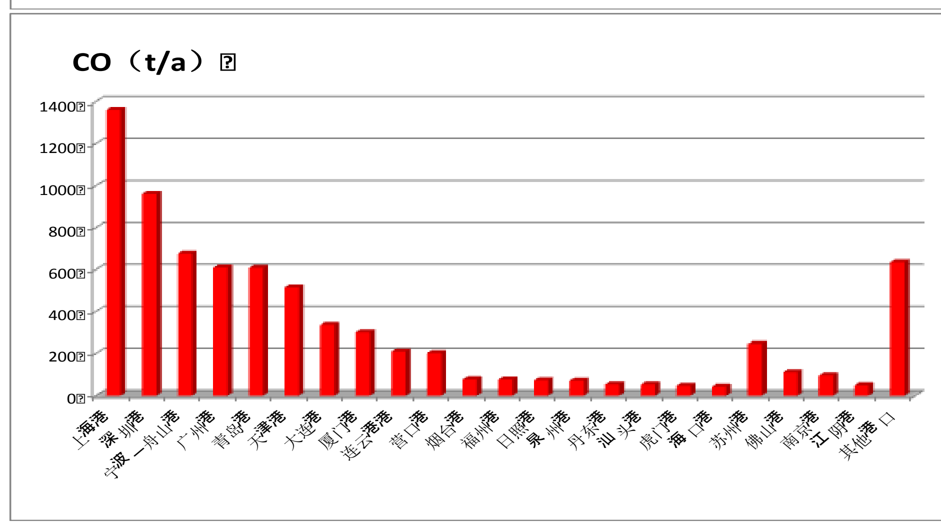
减排对策效果评估案例——集装箱码头油改电（气）减排量

Reduction countermeasures effect evaluation —— Container Terminal Power Changing



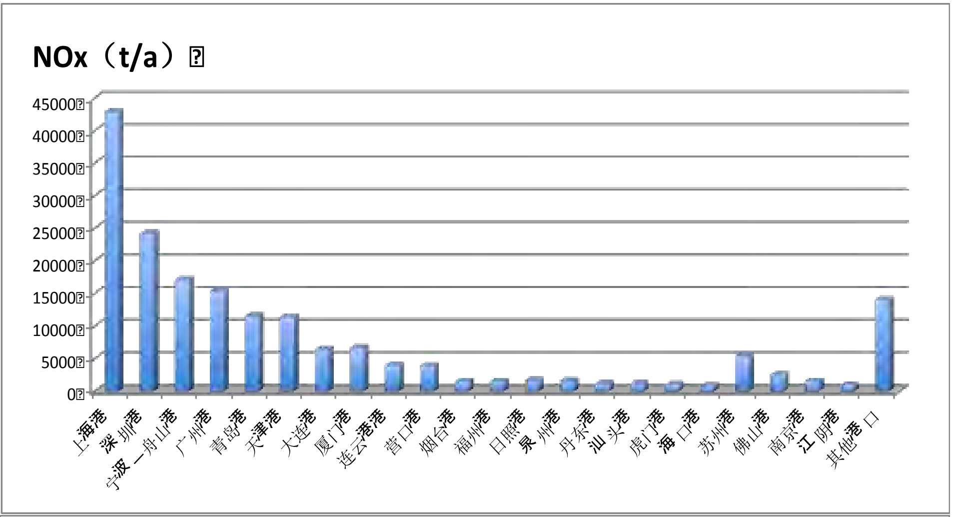


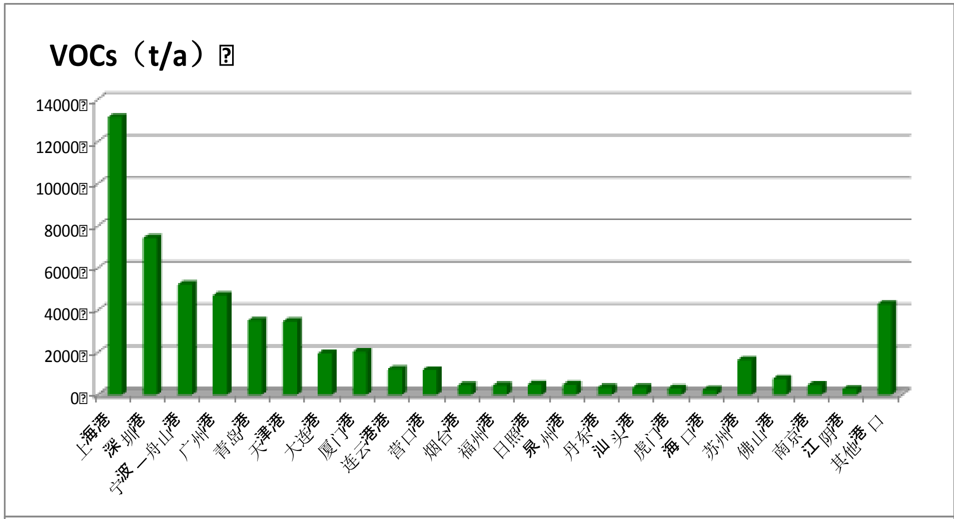


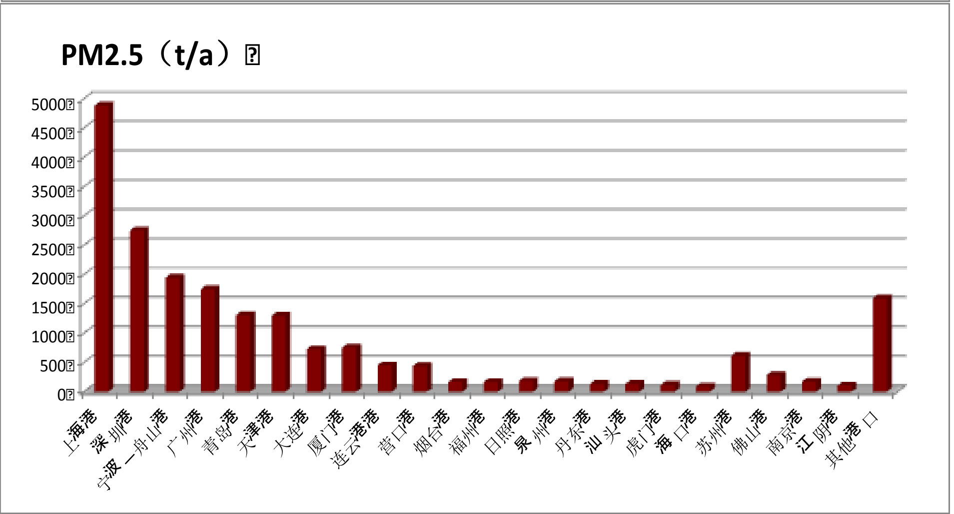


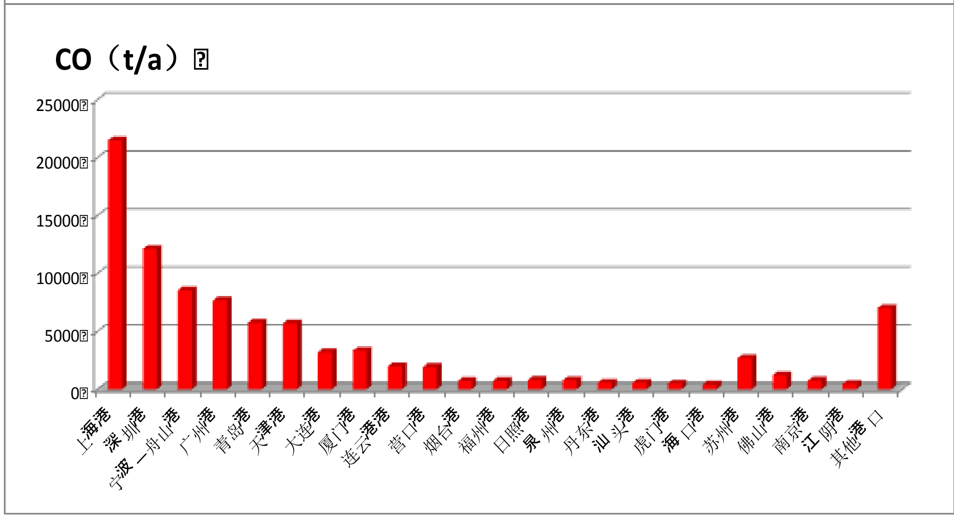
减排对策效果评估案例——铁水联运港口集疏运减排量

Reduction countermeasures effect evaluation —— Container Train-Ship Distribution



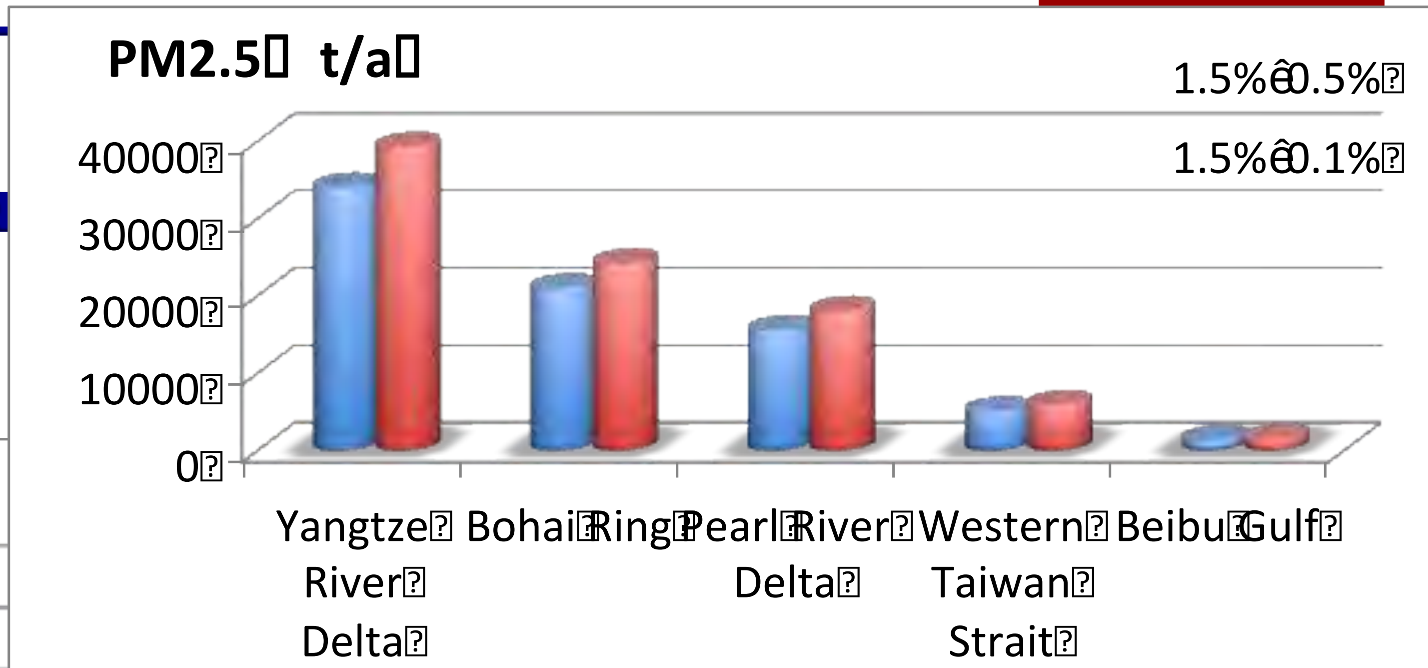


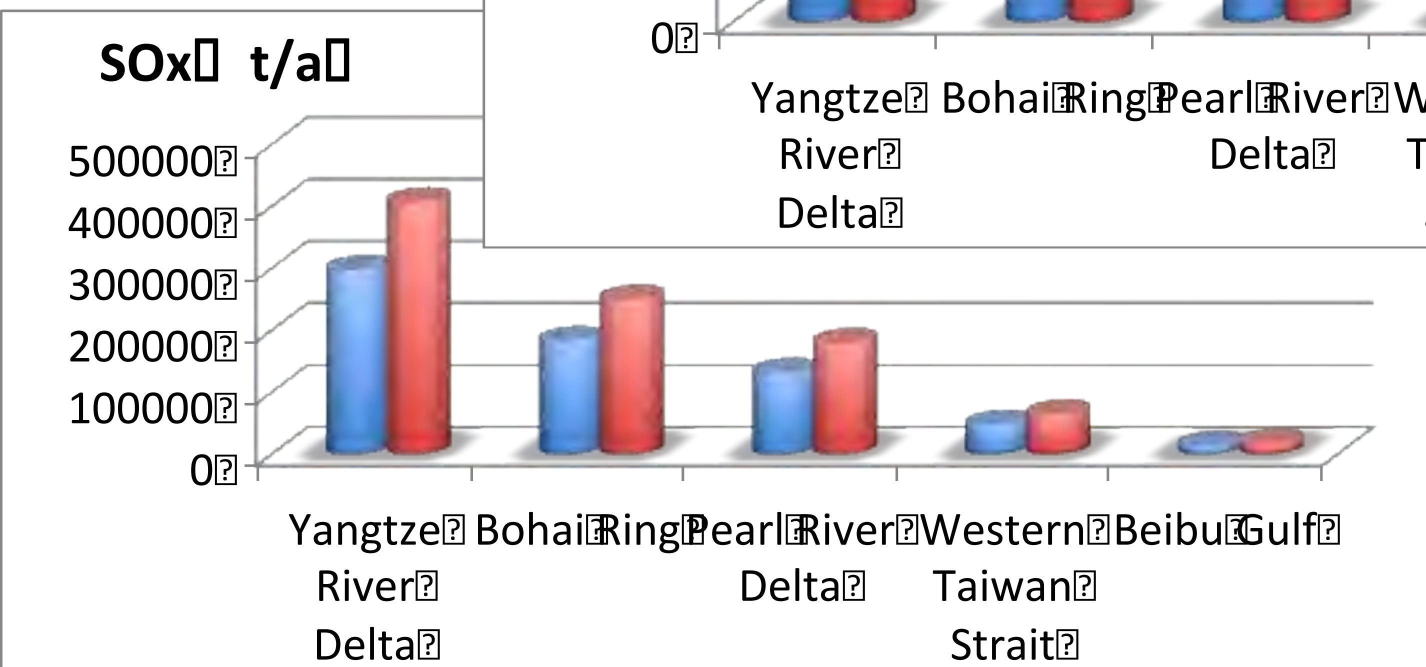




减排对策效果评估案例——排放控制区进出港转油的减排量

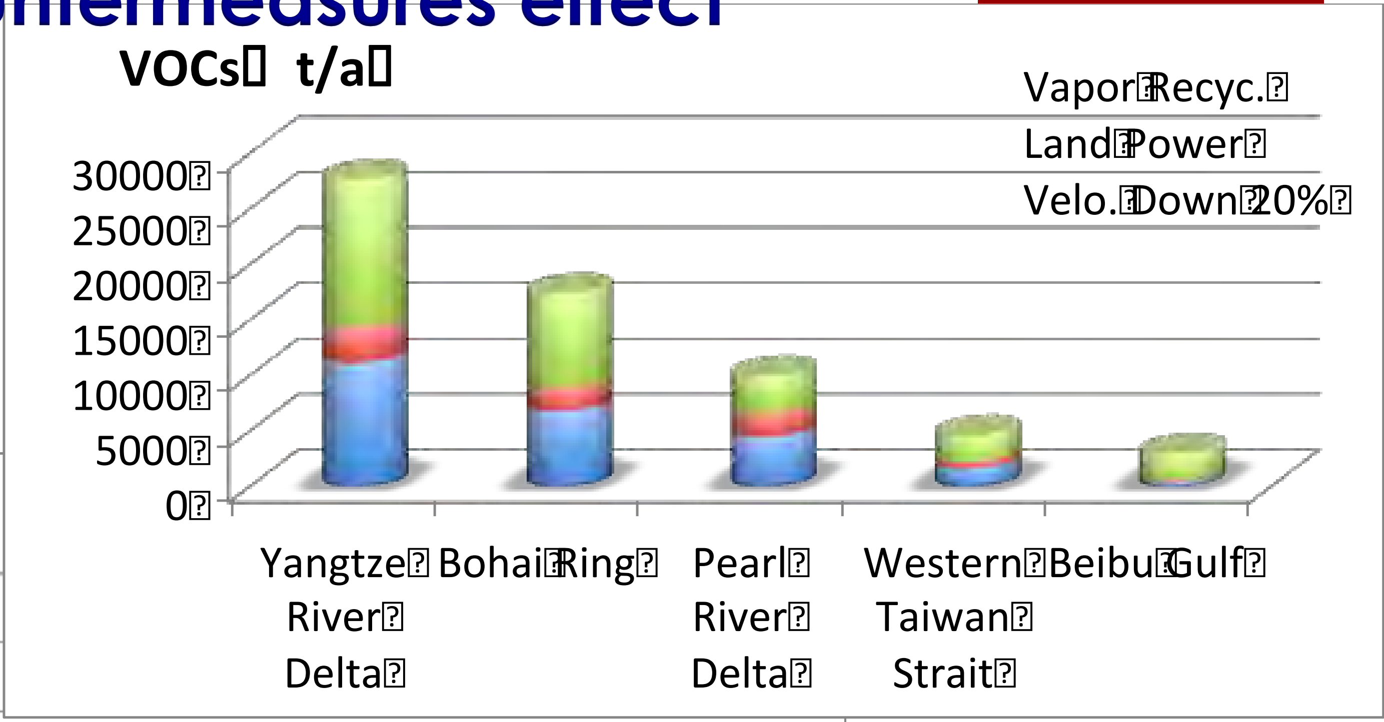
Reduction countermeasures effect evaluation – emission control area changing clean fuel

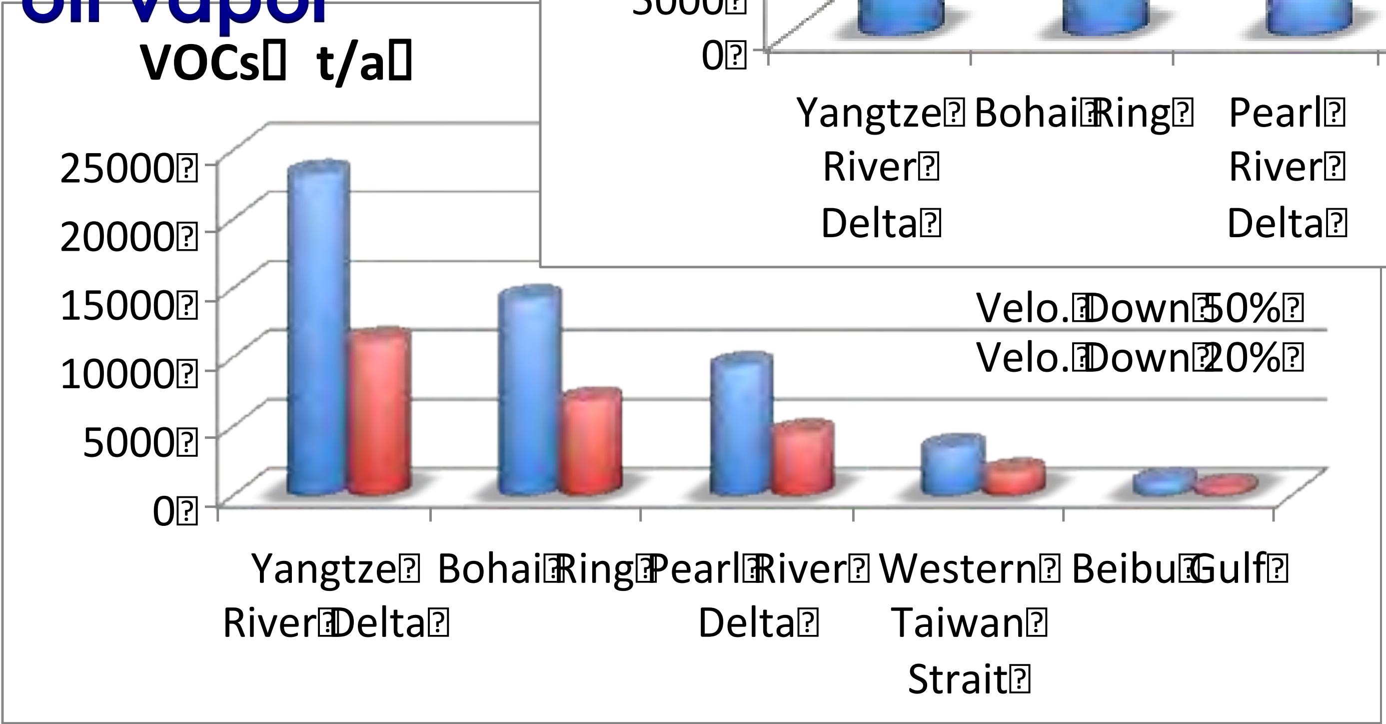




减排对策效果评估案例——减速航行、岸电、油气回收的减排量

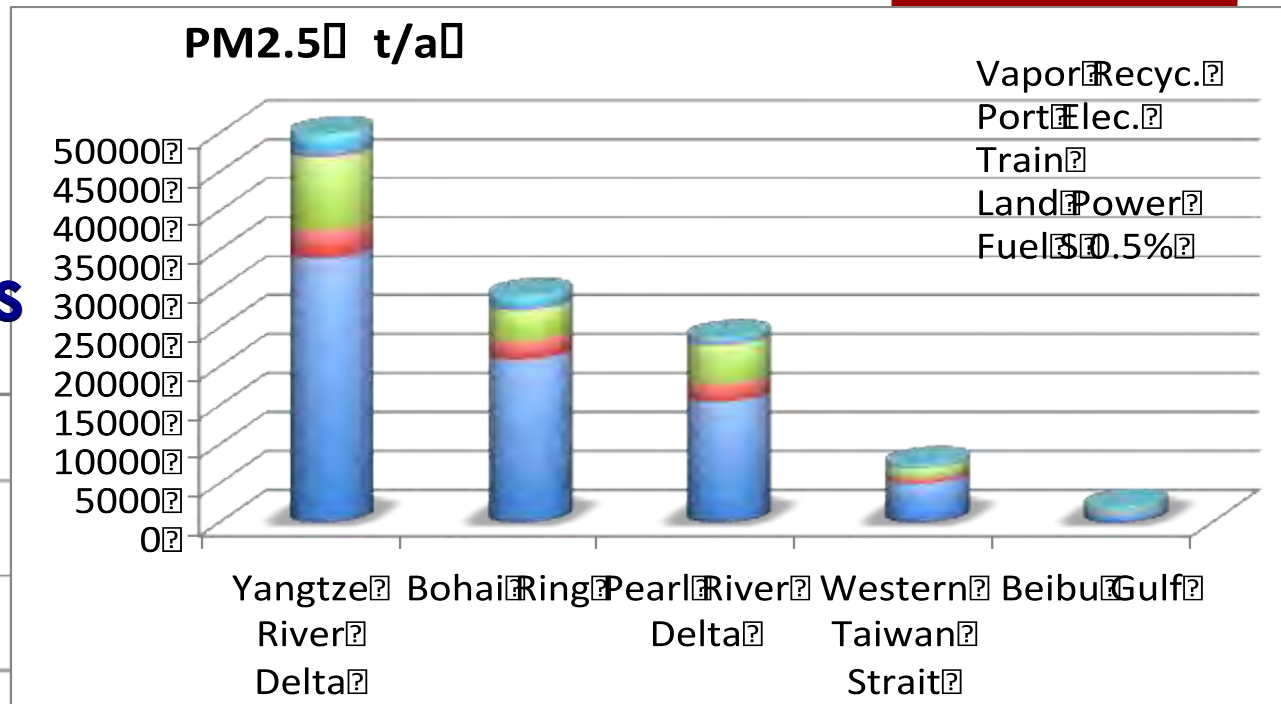
Reduction countermeasures effect evaluation—deceleration, shore power, recovery of oil vapor

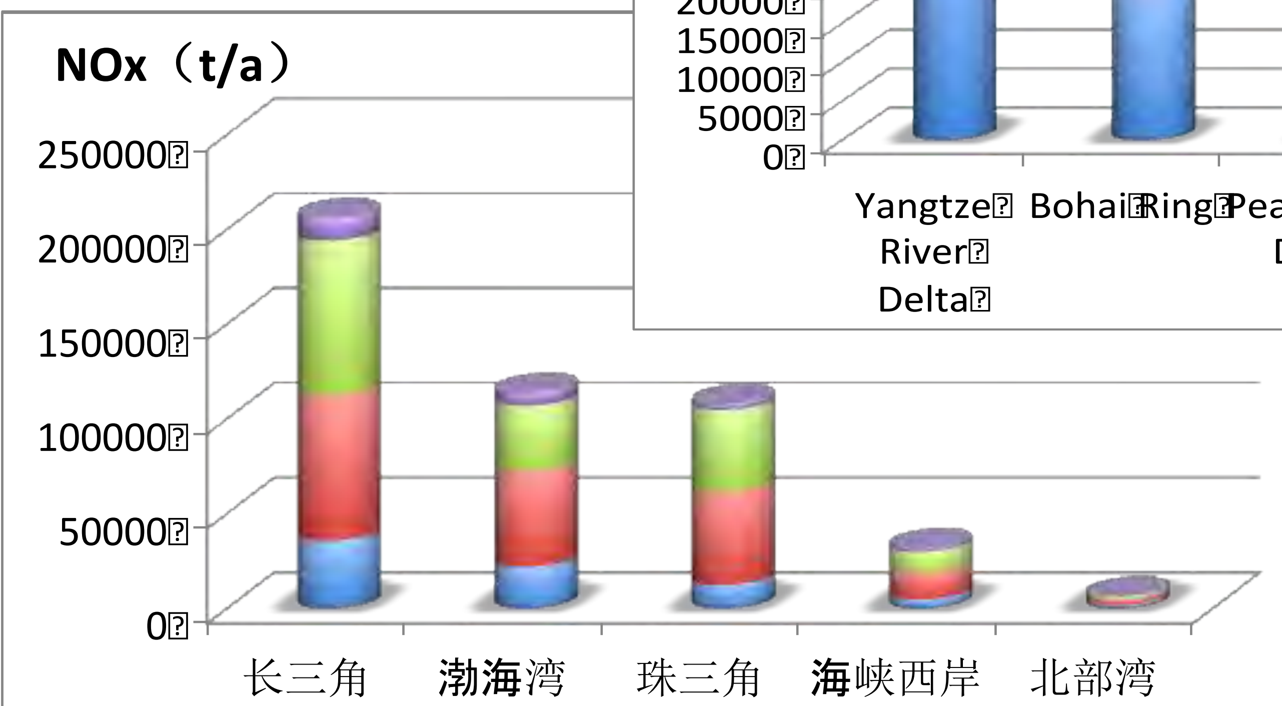




减排对策效果评估案例——组合方案的综合减排量

Reduction countermeasures effect evaluation —— combination of reduction countermeasures





结论及建议
Conclusions and suggestions

- 长三角、环渤海、珠三角、海峡西岸、北部湾等水运密集区，污染物排放量累积叠加效应凸显
  Emissions of pollutants accumulation effect highlights in water intensive areas of Yangtze River Delta, Bohai, Pearl River Delta, the west side of the Straits, Beibu Gulf
- 船舶排放是港口的主要污染源，设立排放控制区是改善沿海港口空气质量的必然选择
  Ship emissions is the main pollution source in port area, the establishment of emission control area is the inevitable choice to improve the air quality of the coastal port
- 进出港船舶采用低硫油、靠港船舶使用岸电、减速航行可显著降低硫氧化物、氮氧化合物、PM2.5、VOCs的排放
  Ships in the harbor, the crude oil by ships to use shore power, reduction of navigation can significantly reduce SOx, NOx, PM2.5, VOCs emissions

结论及建议
Conclusions and suggestions

- 公路集疏运也是港口的主要污染源之一，
  采用铁水联运对各项空气污染物的减排效果显著
  Highway transportation is one of the main pollution source in port, the air pollutant emission reduction effect is significant applying train transportation
- 散装货物空气污染防治应继续予以关注，重点加强油气回收和煤粉尘防治
  Bulk cargo air pollution prevention and control should continue to pay attention to, focus on strengthening the recovery of oil vapor and coal dust control
- 下一步将重点研究分析内河及沿海船舶采用LNG动力的减排效果
  The next step will focus on the analysis of inland and coastal ships using LNG power and reduction effects

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Hainan MSA, Hainan port authority

VECC、Energy Foundation
Shanghai Municipal Environmental Monitoring Center，……

Thank You All！